

## REMARKS

This Reply in response to the Office Action mailed May 24, 2005 ("Office Action"). This Reply is accompanied by a Request for a three-month Retroactive Extension of Time along with authorization to charge the required statutory fee to Deposit Account No. 50-0951, A declaration from Dr. Yuri A. Maletin ("Maletin Declaration"), as well as a cv from Dr. Maletin, also accompanies this Reply.

Claims 1 and 3-25 were pending at the time of the Office Action. All claims were rejected. In this Reply, claims 1, 6, 12 and 14 have been amended, while claims 4, 5, 13, 16 and 17 have been cancelled. No new matter has been added. The amendment to claims 12 and 14 and cancellation of claim 13 overcomes the claim objections and 35 U.S.C. 112, paragraph 2 rejections. Although Applicants respectfully disagree with the Examiner's 35 U.S.C. 112, paragraph 1 rejection of claims 4, 5, 16 and 17 which recite ionic conductivity values, Applicants have cancelled these claims to expedite prosecution of this application.

Before addressing the specification rejection on page 2 relating to Applicants' solid polymer electrolyte (SPE), rejections under 35 U.S.C. 112, paragraph 1, and claim rejections, Applicants will first address the central issue at the core of these various rejections. The central issue is the Examiner's assertion that "solid polymer electrolytes do not [and cannot] contain any solvent". [e.g. see pages 2 and 11 the Office Action]. Applicants respectfully disagree with the Examiner's assertion that solid polymer electrolytes cannot any solvent as explained below.

First, the examiner asserts on page 3 under "claims analysis" that:

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Note the specification states lithium batteries having polymer electrolytes are generally configured as gel-type polymer electrolyte which have liquid intermixed with a selected polymer electrolyte matrix material. The polymer electrolyte functions as a separator, being interposed between the cathode and anode films of the battery (page 5, lines 15-18). Thus, the modified polymer material of the present invention functions as a separator.

Note the "polymer electrolyte" of the claimed invention is a two phase material because the claims recite a gel electrolyte (C-PVC is solid part and solvent is liquid part).

Applicants note that the page 5 excerpt relied on by the examiner is the background section of Applicants' application where the conventional gel electrolytes are reviewed. This background section does not support any finding that Applicants' electrolyte is a gel-type (2-or more phase) electrolyte.

As will be demonstrated below, solid polymer electrolytes can include solvents, despite the fact that the solvent is a liquid at room temperature conditions. Such type of solid polymer electrolytes were well known from different technical literature sources prior to the filing date of the above-referenced application.

For example, US Pat. 6,395,419 B1 to Tsuneo Kuwahara et al. filed Feb. 12, 1998 is entitled "Solid polymer electrolyte, method of making, and electrochemical devices using the same". The abstract which discloses a solid polymer electrolyte impregnated with an electrolyte solution can be viewed below.

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US 6,395,419 B1

(12) **United States Patent**  
**Kuwahara et al.**

(10) **Patent No.:** **US 6,395,419 B1**  
 (45) **Date of Patent:** **\*May 28, 2002**

(54) **SOLID POLYMER ELECTROLYTE,  
 METHOD OF MAKING, AND  
 ELECTROCHEMICAL DEVICE USING THE  
 SAME**

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(73) **Assignee:** **TDK Corporation, Tokyo (JP)**

(\*) **Notice:** This patent issued on a continued pro-  
 ceeding application filed under 37 CFR  
 1.53(d), and is subject to the twenty year  
 patent term provisions of 35 U.S.C.  
 154(a)(2).

Subject to any disclaimer, the term of this  
 patent is extended or adjusted under 35  
 U.S.C. 154(b) by 0 days.

(21) **Appl. No.:** **09/033,441**

(22) **Filed:** **Feb. 12, 1998**

(30) **Foreign Application Priority Data**

**Mar. 26, 1997 (JP)** **9-085030**

(51) **Int. Cl.?** **H01M 10/14**

(52) **U.S. Cl.** **428/429; 429/431.95**

(56) **Field of Search** **429/445, 231.95; 28/623.1-623.5**

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,099,218 A \* 7/1978 Klein et al. 361/433  
 5,418,081 A \* 5/1995 Onda et al. 429/252  
 5,611,100 A \* 5/1997 Eschbach et al. 429/190

**OTHER PUBLICATIONS**

U.S. application No. 08/028,273, filed Sep. 12, 1997, pend-  
 ing.

\* cited by examiner

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**(57) ABSTRACT**

A solid polymer electrolyte is prepared by forming a poly-  
 mer solution containing a filler into a film, evaporating off  
 the solvent from the film, and impregnating the film with an  
 electrolytic solution. The impregnated polymer electrolyte  
 has a swelling factor of at least 2.2. The method is efficient  
 enough to produce the polymer electrolyte at a low cost. The  
 polymer electrolyte is useful in electrochemical devices such  
 as lithium secondary batteries and electric double layer  
 capacitors.

9 Claims, No Drawings

Moreover, Applicants have found that the cited Alamgir reference (U.S. Pat. 5,252,413) also discloses a solid polymer electrolyte. Applicants respectfully point out that the Examiner characterizes Alamgir et al. as having "a solid electrolyte having 50 to 90 wt % aprotic solvent below" :

Alamgir teaches a lithium battery using lithium ion conductive solid polymer electrolytes composed of solvates of lithium salts immobilized in a solid organic polymer matrix. In particular, lithium batteries using solid polymer electrolytes derived by immobilizing solvates formed between a lithium salt and an aprotic organic solvent(s) in polyvinyl chloride (PVC) are disclosed (abstract). The solid electrolyte comprises 50-90 wt% of the aprotic organic solvent, 5-30 wt% of PVC and 5-15 wt% of the lithium salt (col. 4, lines 7-11). Figure 2 depicts results for

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a  $\text{Li/LiMn}_2\text{O}_4$  solid polymer electrolyte cell and Figure 3 depicts results for a carbon/ $\text{LiMn}_2\text{O}_4$  solid polymer electrolyte cell. The lithium salt may be  $\text{LiPF}_6$ ,  $\text{LiClO}_4$ ,  $\text{LiAsF}_6$  or  $\text{LiPF}_6$ . The solvent may be ethylene carbonate, propylene carbonate or  $\gamma$ -butyrolactone (col. 3, lines 35-65). The negative electrode may contain a carbon material, lithium or a lithium alloy such as lithium-aluminum or lithium-tin. The positive electrode may contain  $\text{MnO}_2$ ,  $\text{V}_6\text{O}_{13}$ ,  $\text{V}_2\text{O}_5$ , lithium manganese oxide, lithium polysulfide, polypyrrole, polythiophene or polyacetylene (col. 4, lines 12-42). Alamgir teaches a typical solid electrolyte comprises an aprotic solvent (propylene carbonate) containing a lithium salt ( $\text{LiClO}_4$ ) immobilized in PVC. The electrolyte has conductivities of  $0.9 \times 10^{-3} \text{ ohm}^{-1}\text{cm}^{-1}$  ( $0.9 \times 10^{-3} \text{ S/cm}$ ) at  $20^\circ\text{C}$  (2:18-22).

However, Alamgir teaches that the amounts of Li salt, solvent(s) and polymer in a solid polymer electrolyte is critical, otherwise phase separation will occur and a homogeneous film will not be provided. See the Alamgir Example: (Column 4, lines 1-12), which discloses a composition having 10 weight-percent (w/o) PVC, 15 w/o  $\text{LiClO}_4$  and 75 w/o PC did not form a homogeneous film. On the other hand, homogeneous films could be prepared from the composition of 15 weight-percent (w/o) PVC, 5 w/o  $\text{LiClO}_4$  and 80 w/o PC. Applicants note that electrolyte film in the patent of Alamgir et al. comprises 80% aprotic solvent, and yet a solid polymer electrolyte (SPE) is formed.

The Maletin Declaration also provides sworn expert testimony that solid polymer electrolytes can include solvent. In paragraph 5 Dr. Maletin provides sworn testimony that " Such homogeneous single phase systems including electrolytes according to the invention are generally made possible by strong intermolecular interactions between polymer and solvent molecules under certain conditions, such as the dual solvent process disclosed in the '556 application where the polymer electrolyte goes into solution with the other electrolyte components". In view of the several solid polymer electrolyte references provided by Applicants, together with the Examiner's own words in describing Alamgir {WP267988;1}

and the Declarations of expert witnesses Dr. Maletin and Dr. Shembel, Applicants submit the overwhelming evidence has been provided to demonstrate that solid polymer electrolytes can include solvents, despite the fact that the solvent is a liquid at room temperature conditions.

Accordingly, the objection to the specification copied below should be removed.

*Specification*

The disclosure is objected to because of the following informalities: the specification recites "SPE electrolytes containing ...C-PVC...aprotic solvent (such as PC) and ...a alkali salt". The acronym "SPE" stands for solid polymer electrolyte. SPE electrolytes do not contain any liquid (hence the term solid). The cited section of the specification is describing a gel electrolyte because it is part solid (C-PVC) and part liquid (aprotic solvent). Solid polymer electrolytes are all solid materials and gel electrolytes are part solid/part liquid materials. The specification should be amended such that it is clear and concise. Solid polymer electrolytes do not contain any solvent. See at least page 21, lines 16-20.

Appropriate correction is required.

As amended, claim 1 recites a polymer electrolyte comprising:

a modified chlorine containing polymer having an enhanced chlorine level relative to a chlorine content of an unmodified chlorine containing polymer formed from polymerization of its monomer;

a salt of an alkali metal; and

an aprotic solvent,

wherein said polymer electrolyte is a single phase material comprising said salt and said aprotic solvent integrated with said modified polymer material.

Applicants' recited electrolyte is "a single phase material comprising said salt and said aprotic solvent integrated with said modified polymer material". According to the

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examiner on page 11 of the Office Action it is asserted that Applicants' "specification does not support "a solid homogeneous (single phase) material" ". Applicants respectfully disagree with this assertion as does Dr. Maletin in his Declaration, and Dr. Shembel in her previously provide Declaration. The last paragraph of paragraph 5 of the declaration provides the following testimony:

The polymer electrolyte of the claimed invention formed using the homogeneous process described therein inherently provides a single phase homogeneous polymer comprising material comprising the polymer, the salt and the aprotic solvent, provided the salt loading level is not too high. The salt levels disclosed in the application do not appear high enough to cause phase separation. Such a homogeneous single phase solid system can be formed due to strong intermolecular interactions between polymer and solvent molecules under conditions disclosed in the present application. The single phase result would be clear to one having ordinary skill in the art based on the application.

Although the examiner asserts on page 14 of the office Action that Dr. Shembel's Declaration does not overcome the enablement rejection because "the specification does not state "phase separation does not occur". Applicants respectfully disagree because a specification does not have to explicitly disclose all claimed details. Applicants note that case law as well as the MPEP provide that detailed procedures for making and using the invention may not be necessary if the description of the invention itself is sufficient to permit those skilled in the art to make and use the invention. Thus, a feature clear to one having ordinary skill in the art at the time of the invention does not need to be explicitly disclosed in the application in question.

The relevant portion of MPEP 2164 is copied below:

#### 2164 The Enablement Requirement

The enablement requirement refers to the requirement of 35 U.S.C. 112, first paragraph that the specification describe how to make and how to use the invention. The invention

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that one skilled in the art must be enabled to make and use is that defined by the claim(s) of the particular application or patent.

The purpose of the requirement that the specification describe the invention in such terms that one skilled in the art can make and use the claimed invention is to ensure that the invention is communicated to the interested public in a meaningful way. The information contained in the disclosure of an application must be sufficient to inform those skilled in the relevant art how to both make and use the claimed invention. *Detailed procedures for making and using the invention may not be necessary if the description of the invention itself is sufficient to permit those skilled in the art to make and use the invention.* (italics for emphasis only)

In view of the above, the enablement rejection should be removed.

Turning now to claim rejections based on cited art, claims were determined to be rejectable under 35 U.S.C. §102(e)/103(a) as being anticipated and alternatively unpatentable over previously cited U.S. Patent No. 6,617,078 to Chia et al. ("Chia '078") or U.S. Patent No. 5,389,463 to Chang et al. ("Chang '463"), or under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 5,252,413 to Alamgir et al. ("Alamgir '413") in view of Chang '463 or view of Chia '078.

Chia and Chang both form gel polymer electrolytes which include at least 2 phases. The Linden reference provide by the Examiner describes the Chia and Chang gel electrolytes, but not Applicants' electrolyte. As correctly noted by the Linden reference provided by the examiner, the gel structure results from "trapping liquid solutions of lithium salts in aprotic solvents into a solid polymer matrix such as polyacrylonitrile (PAN)". In contrast, the homogeneous method described in the present application places the aprotic solvent, the salt and the C-PVC polymer in a common solvent to form a homogeneous solution (liquid), which upon drying which drives off the common solvent forms a single phase material.

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Applicants' electrolyte is structurally distinct when compared to conventional gel electrolytes. The single phase material is a salient difference. The AFM data provided with Dr. Shembel's declaration also evidences the distinction between known electrolyte and applicants' electrolyte. According to Dr. Maletin in paragraph 6 of his Declaration:

I have reviewed the comparative AFM data provided with Dr. Shembel's Declaration filed in this case. Such data clearly demonstrates the structural differences between the claimed single phase polymer electrolyte and the gel electrolytes disclosed in the Chia and Chang. Based on Dr. Shembel's sworn testimony the structure analyzed in Fig. 1 was a single phase electrolyte according to the invention formed from a lithium salt ( $\text{LiCF}_3\text{SO}_3$ ) solution in an aprotic solvent (PC) which was added into previously prepared C-PVC solution in tetrahydrofuran (THF). Solutions, prepared in this fashion, were poured onto a glass support and dried, first at room temperature for 24 h and then in a vacuum at  $45^\circ\text{C}$  for 48 h. These steps follow the method described in the '556 application. The resulting electrolyte films are single phase homogeneous systems that have a uniform distribution of the all components in electrolyte as evidenced by the very flat electrolyte surface shown in Fig. 1.

Moreover, paragraph 8 of the Maletin Declaration provides the following testimony:

Comparative analysis of the AFM polymer electrolytes based on C-PVC shown above demonstrates that homogeneous single phase electrolytes produced from drying homogeneous solutions according to the '556 application is clearly structurally distinguishable as compared to the multi-phase gel electrolytes formed using separator impregnation with liquid electrolytes as described in Chang and Chia.

Since based on the weight of the evidence Applicants' claimed invention recites [and is] "polymer electrolyte [being] s a single phase material comprising said salt and said aprotic solvent integrated with said modified polymer material, while Chia and Chang are conventional gel-electrolytes which are at least 2 phase materials, Applicants submit the amended claim 1 and 12 and their respective dependent claims are patentable over Chia and Chang.

Applicants now address the asserted combination of Alamgir (solid polymer electrolyte with standard unmodified PCV) together with Chia or Chang (gel electrolyte with C-PVC electrolytes) to reject Applicants' claimed invention as being obvious.

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As noted above, Alamgir teaches that only certain amounts of Li salt, solvent and PVC allow formation of homogeneous films as some of his examples failed to provide homogeneous films. This evidences that homogeneous (single phase) electrolytes require critical combinations of polymer, salt and solvent, in both species and concentration. Since C-PVC is known to have significantly different properties as known in the art and by the examiner, it cannot be determined whether C-PVC will even form a homogeneous single phase electrolyte with some solvent/salt combination. Paragraph 9 of the Maletin declaration provides the following testimony:

I cannot agree with the examiner's assertion that it is obvious to substitute the chlorinated PVC of Chang or Chia with Alamgir's electrolyte to arrive at the claimed invention in the present application. The change in polymer chemical structure and composition can essentially change its interaction with other molecules, e.g., solvents and salts. And as noted above, this is the intermolecular interaction that enables to obtain a single phase solid electrolyte. Such homogeneous electrolytes may have different and/or limited stability in different electrolytes, and the result now claimed by Applicants can hardly be obvious *a priori*.

Moreover, several secondary considerations are present which provide strong evidence regarding the non-obviousness of the claimed invention.

i) Applicants' electrolyte provides unexpectedly high Li ion conductivity, such as lithium ion conductivity of up to .108 S/cm<sup>2</sup> disclosed in the application (Example 6, page 26, line 2). For a 100  $\mu$ m thick electrolyte layer, the resulting Li ion conductivity would be  $1.08 \times 10^{-3}$  S/cm. This value is 20% higher than the best value reported by Alamgir ( $0.9 \times 10^{-3}$  S/cm). Moreover, the data disclosed in FIG. 2 of the application (the resistivity of the passivating layer formed on a Li electrode surface of a Li-SPE-MnO<sub>2</sub> system, from SPEs based on PVC and C-PVC), and FIG. 3 (the system impedance of a Li-SPE-Li system, the SPE formed from PVC) are all recognizable by those having ordinary skill in the art as outstanding and unexpected results.

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ii) Such results led to significant commercial success of the invention. The assignee of the present invention procured a license with Itochu for the present invention which was previously submitted as evidence in this case and is recorded at the PTO.

Finally, the examiner's disbelief that a polymer electrolyte having a solvent that is a liquid at room temperature could be a homogeneous single phase material should be strong evidence of patentability assuming some experts may hold the same view. Disbelief regarding aspects of a claimed invention is regarded as strong evidence of patentability as note in MPEP (copied below) 716.05 copied below:

### 716.05 Skepticism of Experts

"Expressions of disbelief by experts constitute strong evidence of nonobviousness." *Environmental Designs, Ltd. v. Union Oil Co. of Cal.*, 713 F.2d 693, 698, 218 USPQ 865, 869 (Fed. Cir. 1983) (citing *United States v. Adams*, 383 U.S. 39, 52, 148 USPQ 479, 483-484 (1966)) (The patented process converted all the sulfur compounds in a certain effluent gas stream to hydrogen sulfide, and thereafter treated the resulting effluent for removal of hydrogen sulfide. Before learning of the patented process, chemical experts, aware of earlier failed efforts to reduce the sulfur content of effluent gas streams, were of the opinion that reducing sulfur compounds to hydrogen sulfide would not adequately solve the problem.).

"The skepticism of an expert, expressed before these inventors proved him wrong, is entitled to fair evidentiary weight, . . . as are the five to six years of research that preceded the claimed invention." *In re Dow Chemical Co.*, 837 F.2d 469, 5 USPQ2d 1529 (Fed. Cir. 1988); *Burlington Industries Inc. v. Quigg*, 822 F.2d 1581, 3 USPQ2d 1436 (Fed. Cir. 1987) (testimony that the invention met with initial incredulity and skepticism of experts was sufficient to rebut the *prima facie* case of obviousness based on the prior art).

In view of the evidence submitted above, as well as other evidence of record in this case, Applicants submit that the asserted finding of obviousness based on the combination of Alamgir (solid polymer electrolyte with standard unmodified PCV) together with Chia or Chang (gel electrolyte with C-PVC electrolytes) should be removed. Accordingly, Applicants submit that amended claims 1 and 12 and their respective dependent claims are patentable over Alamgir in view of Chia or Chang.

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Applicants have made every effort to present claims which distinguish over the prior art, and it is believed that all claims are in condition for allowance. However, Applicants invite the Examiner to call the undersigned (direct line 561-671-3662) if it is believed that a telephonic interview would expedite the prosecution of the application to an allowance.

Respectfully submitted,

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